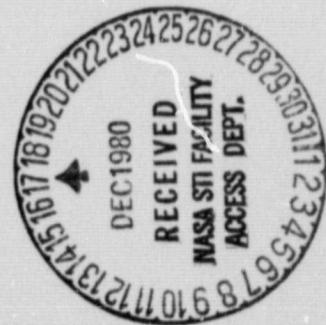
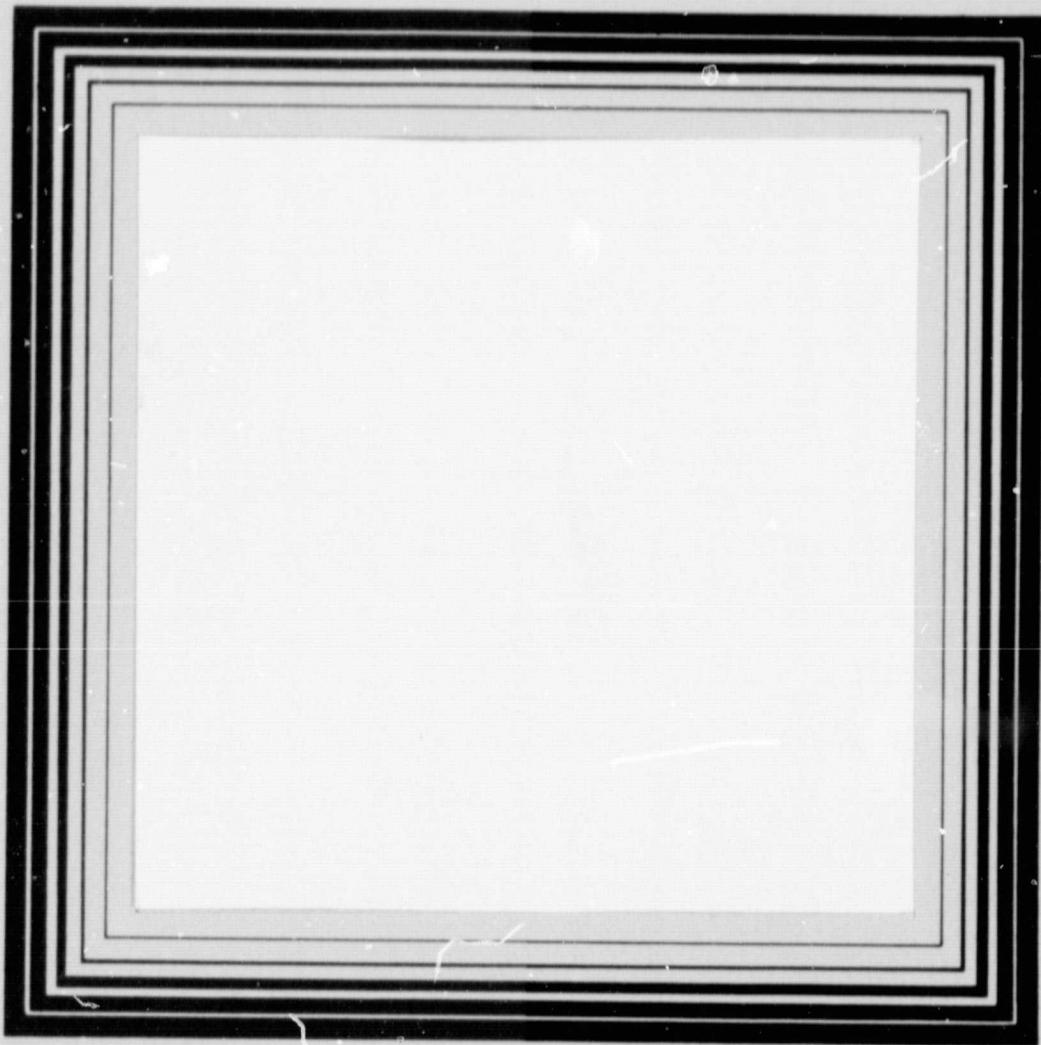


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NASA CR-160044



Galileo Electro-Optics Corp.

NASA-CR-160044 FIBER OPTIC COMBINER AND  
DUPLICATOR (Galileo Electro-Optics Corp.)  
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CSCL 20F  
Unclassified  
39957



**Galileo Electro-Optics Corp.** Galileo Park, Sturbridge, Massachusetts 01518, (617) 347-9191

**FINAL REPORT**

**Fiber Optic Combiner and Duplicator**

(Contract No. NAS5-23250)

**Submitted To:**

National Aeronautics & Space Administration  
Goddard Space Flight Center  
Greenbelt, Maryland 20771

30 November 1979

Copy No. 3



Galileo Electro-Optics Corp.

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### INTRODUCTION AND SUMMARY

NASA Contract #NAS5-23250 was awarded to Galileo Electro-Optics Corporation in June of 1973. This Contract required the development of two optical devices, one to take two images as inputs and to present their arithmetic sum as a single output, the other to take one image as input and present two identical images as outputs. These two components were basic elements in the two-dimensional optical computer which NASA planned to employ in future spacecraft. The complete Work Statement is attached as Appendix A.

The design concept described in Galileo Proposal RFP#5-34443-144, dated 6 February 1973, required the development of tooling and the modification of existing fiber drawing machines to fabricate an interleaved fiber optic assembly having two outputs and a common input. The device was required to be a coherent layered assembly of 256 100 $\mu$  pixels, set in alternate rows with the two outputs at an angle of 24°. The interleaved assembly had extremely rigid requirements as to the absolute position of each fiber in both the vertical and horizontal directions.

In basic concept, this program exceeded the "state-of-the-art" of fiber optics components and through the work performed established new capabilities of fiber optics assemblies at Galileo Electro-Optics Corp. Many of the engineering tasks that were required to build an interleaved device were accomplished. Significant engineering time was invested in establishing precision fiber optics drawing capabilities, real time monitoring of the fiber size and exact measuring of fiber optics ribbons. Various assembly procedures and tooling designs were investigated and prototype models were built and evaluated that established technical assurance that the device was feasible and could be fabricated. Although the interleaver specification in its entirety was not achieved, the techniques developed in the course of the program have improved the quality of images transmitted by fiber optic arrays by at least an order of magnitude. These techniques are already being applied to the manufacture of precise fiber optic components for other Government agencies.

In April of 1979, Galileo Electro-Optics Corporation was formally notified that Goddard Space Flight Center no longer required the completion of NASA5-23250 and that Goddard wished to negotiate the end of the Contract based on work completed. This Final Report is submitted as a requirement of that negotiation and it is intended to summarize all major activities and analyze each prototype model produced.



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### PROGRAM SUMMARY:

Initially in the Contract, drawing parameters were established, concept of assembly techniques and tooling design completed, and special materials ordered for the program. It was Galileo's concept to utilize the control of fiber size and the square fiber format to establish the building blocks of the interleaver device. Galileo was unaware of the exacting details demanded by these building blocks or, the subtle influences of the environmental in the form of drafts that effect the drawing control, dirt that impairs the pushing of adjacent fibers into a perfect ribbon, vibration in the fiber because of the initial design of the drawing equipment, and the materials handling technique that would subsequently require development.

Many alternate engineering solutions exist today as a direct result of the NASA Contract #NAS5-23250.

- Electronic feedback to the fiber drawing take-up mechanism has established fiber size control to  $\pm .25\%$  and Galileo utilized the equipment designed and fabricated for precision fiber placement under NASA Contract #NAS5-23250 (Precision Traverse Device, Twenty-Seventh Monthly Report) to fabricate ribbons to less than .25% about a tightly controlled mean actual dimension
- The electronic feedback theory of drawing was conceived during interleaver draws, actual size monitoring equipment was purchased for real time monitoring of fiber size. Devices similar are now used to drive an amplifier that controls the take-up system's actual linear speed.

### Equipment Design and Facility Design

Drawing equipment has made major gains due to the work performed on the interleaver contract. Systems are now designed to be totally isolated from other activity in the area, and the input tower and take-up mechanism totally independent of the building. Machines utilize floor mounted, vibration isolated stable designs.

The need to eliminate particulate matter from impacting the positioning of fiber to fiber within an array became painfully obvious during the NASA Contract. Upgrading facilities utilizing Class 1000 Clean Room air, handling equipment, and modular laminar flow Class 100 filters are elementary to present day state-of-the-art drawing.

In summary, NASA Contract NAS5-23250 headed the forefront of fiber ribbon technology and equipped Galileo Electro-Optics Corp. with the engineering data to justify alternate equipment design, proper facilities design, and upgraded materials handling techniques to be a leader in the technically difficult components assemblies required by the Government today.

## BACKGROUND

Immediately following Contract Award in June of 1973, the activity to establish ribbon quality of a square monofiber draw and the study of the assembly operations were initiated. Trade-offs as far as numerical aperture, transmission and fiber geometry were analyzed and included in the First Monthly Report. Concept of an assembly procedure was established that used identical dead fibers as the spacing between active layers of the interleaver. This resulted in a detailed design and procurement of GEOC P/N 3557111, NASA Interleaver Assembly Fixture (Appendix B).

The objective of the next few months was to optimize the fiber shape (geometry) through the use of thermal variations in the draw process, speed vibrations on both the input and output systems, and variation of the pre-form size. The series of experiments pointed out that several additions to the proposed manufacturing plan had to be implemented.

Inter-fiber gaps caused the overall dimension of the ribbon to be larger than the tolerance of the interleaver. Handpacking around an entire circumference of an 11-1/2' drum was difficult to control. Due to the momentum of the take-up device, individual fiber size variations were greater than expected.

During this time period, many of the tools required in the assembly sequence were designed and procured. A special ribbon cutting tool for stripping the 512 fiber building blocks, fiber pressing thermal controls, and the grinding and polishing tools became ready for the assembly sequence.

In January of 1974, a pair of interleavers were fabricated utilizing all of the processes that had been optimized to date. Automatic packing of fiber with an air jet and use of a smaller drum diameter (4') to wind and maintain size control were implemented. Transmitted image showed large fiber displacement due to accumulated error in fiber size and the epoxy holding individual ribbons failed to support the ribbon during pressing and curing. It was observed that individual ribbons were stacked into the fixture gradually "Haystacking" and causing the overall assembly to sag and not hold geometry.

Efforts were concentrated on changes in the manufacturing process during the following month. Ribbon shims to support the outer areas of the fiber assembly were designed to eliminate the "haystacking" problem. An attempt to put a strong but uniform layer of epoxy on the ribbon by spraying instead of brush painting showed a great deal of promise, but due to the air velocity of the spray creating fiber to fiber displacement this process was abandoned.

During April another prototype interleaver device was delivered to Goddard Space Flight Center. This unit showed substantial improvement in optical performance because the fiber to fiber displacement had been minimized and the "haystacking" problem with the use of the metal shims was a major improvement. The device clearly pointed out that in order to reach the outlined specification of the interleaver matrix, total deviation in fiber size

had to be held to just a few microns. It was at this time that we elected to purchase a grooved drum to insure that absolute position of the fiber could be maintained independent of the actual fiber size.

The grooved drum design, modification of the assembly fixture, and methods to increase the assurance that a ribbon was placed in a correct angular position were incorporated into the assembly process. During this extensive period, major modifications dedicated to the fabrication of precision ribbons were installed.

- Synchronization of the traverse mechanisms to the drum.
- Use of greater than  $100\mu$  center-to-center Ronchi ruling to inspect ribbons and qualify them for assembly. The mold was also modified to observe the angular position after placement in the mold with another spring loaded Ronchi ruling device.

It was unanimously decided between NASA and Galileo Electro-Optics Corp. that in a complex assembly such as an interleaver, it was difficult to determine the exact cause of many of the defects seen in the assembled prototypes. The majority of technical conferences identified not less than ten suspect operations. During July of 1975, Galileo constructed a single axis fiber ribbon lay-up from precision square monofiber material. This experiment demonstrated the ability to hold fibers in a perfect XY configuration where all variables of fiber size and ribbon size were removed and the sides of those ribbons supported during the press. The experiment was repeated using one wall of the pressing fixture with the same quality ribbons (selection process). The ribbons bulged and failed to show anything close to what was produced in the two wall fixture. This experiment would become a new basis for assembly support and fixture design (See Appendix C, XY Configuration Test).

Extensive modification to the drawing tower mechanism were implemented from July through September of 1975. A real time monitoring system was installed to enable fast feedback to the operator on any change in fiber size that occurred during the run. By use of an ink pad marking system on a solenoid, accurate fiber ribbon counts and measurements could be done. Machine layout for the synchronization mechanism was completed. These modifications gave technical justification to the claim that "perfect ribbons" were producible and methods of selection well established.

During October of 1975, NASA personnel visited Galileo Electro-Optics Corp. for a Program Status Review. At that time, it was agreed that the pressing fixture must be modified to simulate the "U" fixture used for the fabrication of the test block. Shims were designed to have the tolerances of the now "perfect ribbon" with the angle and thickness requirements requiring machined pieces rather than stamping. Efforts were primarily on analysis and preparation for a test block to be fabricated with side supports and shims. It was agreed during NASA's visit that Galileo Electro-Optics Corp. would continue to use Contract funds and arrive at a definite decision as to the feasibility of our approach, proven by fabrication of one (1) in-spec Combiner Duplicator.



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In this case, further funds were to be required for the remaining three (3) called for in the Contract. In the event the Combiner Duplicator is unsuccessful with present technology, a new proposal must be generated if an extension is desired.

As planned, a test block was fabricated during December. It was fabricated 20 layers high with shims placed in the fixture to simulate the wall of a "U" fixture. The results of this test block proved that the shims definitely act as a wall of a fixture and restrain the ribbons from moving. The edges of the shims, however, were not held in a straight line and as a result the block did not show the required coherency. It was decided, at this time, that Galileo would produce a method of holding the shims together to incorporate into the next test.

During January of 1976, a test block was fabricated 40 layers high with shims placed in the fixture to simulate the wall of a "U" shape fixture. In contrast to the previous block fabricated, the shims were stacked and aligned first and then fastened rigidly together. The purpose of this approach was to provide a row of shims that would simulate the wall of the "U" fixture more closely than independently placed shims. The results indicated that better control was achieved and the extremely tight tolerance on the fiber position was transferred to an extremely tight tolerance on the shim position. It was agreed that this approach would more than likely cause misplaced ribbons due to assembly complications. Upon evaluation of the block for coherency, two ribbons were grossly misplaced. Instead of contacting the edge of the shim, they had overlapped the shim. In pursuit of an alternate method, a fixture for making fused and polished ribbons was designed (See Appendix D, Fusing/Polishing Fixture, GEOC P/N 3557047). This fixture would be used to produce a curved ribbon.

At this point in time, a meeting was held in Washington to evaluate progress to date and potential of future efforts. It was agreed that Galileo Electro-Optics Corp. would continue to fabricate the fused/polished fixture approach. A Proposal was submitted to NASA on 5 March 1976 requesting modifications on NASA Contract #NAS5-23250. Galileo Electro-Optics Corp. proposed new methods for the assembly of the interleaver. Instead of four (4) Interleavers, one (1) Engineering Feasibility Model would be required by Galileo during a performance period of 47 months (Total CPFF \$101,267.42).

Two Phases are detailed below describing our proposed new procedure.

- Phase I - Ribbon Assembly and Testing

In Phase I the required number of dried but uncured fiber ribbons are placed in a fusing/polishing fixture, where the stack of ribbons is pressed, cured to form a rigid fused mass, and finally polished. With the fiber ends polished the position of the individual fibers within each ribbon can be checked optically in the fusing/polishing fixture. Finally the stack is separated into single ribbons; the



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ribbon separation is accomplished by placing a shim of aluminum or stainless steel foil between each fiber ribbon. The aluminum shim is sprayed on both sides with a mold release, and the ribbons can easily be separated from the aluminum shims. The pressing and curing process presses the aluminum shims into contact with the fibers in each ribbon. The thickness of the ribbon is therefore controlled by the fiber size.

Phase I began with the fabrication of the fusing/polishing fixture, and continued with the preparation of fused ribbons. The fused ribbons were inspected for fiber alignment, broken fibers, and dimensional accuracy.

• Phase II - Interleaver Assembly and Testing

Once the cured ribbons are inspected and approved by the technical monitor at NASA, Galileo Electro-Optics Corp. will proceed with the design and fabrication of the lay-up and final assembly fixture. Galileo has identified design criteria which must be met in the design of the fixture. The basic purpose of having the ribbons angled and polished is to have a method for in-process inspection of the interleaver as it is assembled. The assembly fixture will therefore have a rectangular optical pattern on the (combined-image) end of the interleaver during the lay-up. This pattern will act as a ruling for the alignment of the ribbons. The rectangular pattern will allow alignment of both the X and Y direction. The combined end of the interleaver will have an independent device which will hold the ribbons in the desired configuration. This will allow inspection of both the coherency of the ribbons, and the accumulated height of the ribbons.

The negative pressure will hold the ribbons against the wall of the fixture, thereby insuring alignment at the duplicate image end. Once all the ribbons are in place, the two duplicating image ends will be clamped in place. At this point another series of in-process checks will be initiated to prove that the spacing in the Y direction is accurate, and that the ribbons have in fact all contacted the edge of the fixture. Once this has been verified, the unit will be potted. Holes or slots will be provided to inject epoxy around the sides of the interleaver. Since the image faces are being held, they will not move during this operation. Once the unit has cured, the faces of the interleaver will be soaked with a fluid epoxy and a final polish will be done.

After review of our requested modifications, NASA found our Proposal acceptable. NASA suggested that the remaining three (3) interleavers be postponed as a secondary phase and requested that Galileo Electro-Optics Corp. modify our program to include this phase in our funds.

Phase I of our Proposal was successfully completed during September producing five (5) sample ribbons. At this time, Galileo continued on to construct an intermediate demonstration fixture to prove feasibility of an interleaver (Phase II).

During January of 1977, a design was completed for a test fixture to demonstrate correct positioning, by partial vacuum forces, of ribbons prepared during Phase I of our Proposal. Purchase orders were prepared and completed for this test fixture during the following month. Upon completion of the test fixture, ribbons were trimmed to proper width and placed in the vacuum fixture with the aid of partial vacuum forces. The stack was lightly tacked in place by the application of moderate heat and pressure. The stack was then cut and tested for coherency. Results indicated that upon removal from the fixture, the block was found to contain a number of inverted ribbons. These caused the block to fall apart and it had to be re-fused. The end result showed a number of severe dislocations around these areas. However, it was noted that at the edge which was lined up, the coherency was nearly perfect. Since the coherency was good at the vacuum port the fixture should produce the required results. At this time, blocks were further analyzed and fused ribbons fabricated.

The design of a vacuum fixture to use fused and polished ribbons continued on through August. Due to extended deliveries of designs and machining, Galileo Electro-Optics Corp. requested an extension to NASA Contract #NAS5-23250 at no additional cost to the Government.

All fixtures were received and through Quality Control by mid September and the shims were fabricated. Galileo was now ready to begin fabrication of a prototype interleaver upon receipt of Contract extension.

The first step in the assembly procedure was the manufacture of ground and polished ribbons. These ribbons were fabricated in specially designed fixtures for use in the final assembly. The advantage of using this fixture to make a fused fiber optic ribbon was that the optical alignment of the fibers can be verified in the fixture. Any ribbons showing gaps or non-coherency can be rejected when the ribbons are removed from the fixture. The next step in the assembly was to place these ground and polished ribbons into the assembly fixture. The alignment test mask used remained the same as the image buss mask designed on another Contract. This allowed verification of spacing in both the X and Y dimensions. The assembly was monitored under a stereoscope ribbon by ribbon during the assembly and once the assembly was built to incorporate all 256 layers, the unit was potted and epoxied and a final grind and polish performed.

During March of 1978, all the planned activities in anticipation of completing the prototype were performed. The assembly was made, and the units evaluated. The resultant prototype was found to be well out of specification. Galileo Electro-Optics Corp. felt, at this time, that the assembly procedure needed considerable refinement and additional tooling to bring the present coherency down to the specification limits.



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## APPENDIX A

### Statement of Work

### Development of an Image Combiner and an Image Duplicator

DEVELOPMENT OF AN IMAGE COMBINER AND  
AN IMAGE DUPLICATOR

INTRODUCTION

In future spacecraft, such as operational Earth Resources missions, the prime source of input to the spacecraft will be information in the form of images. To handle the very large amounts of such data some type of parallel processing must be carried out on board the spacecraft. One method of performing such parallel processing involves using noncoherent optics in a two dimensional computer. Two components essential to the development of this computer are a small, efficient device to combine two images, and a device to duplicate images.

This request for proposals is for development of a device to take two images as inputs and present their arithmetic sum as an output. A second device, (perhaps the first device used in reverse), will take one image as input and present two identical images as outputs. In both devices no type of scanning is permitted and no moving parts are allowed. Figure 1 is a schematic of the type of devices envisioned.

STATEMENT OF WORK

There shall be two pair of devices designed, fabricated, tested, and delivered, that is, two combiners and two duplicators. One pair of devices shall be connected together such that they may be separated later. This pair of connected devices shall take two images as inputs and present two images representing the arithmetic sum of the inputs as outputs.

## DESIGN GOALS FOR IMAGE COMBINER

**Input:** There shall be two input image surfaces on one side of the device. Each of these surfaces shall be no larger than 26 mm square. Each surface shall have the capability of being organized into a matrix of 128 image elements by 128 image elements on at most .2 mm centers.

**Output:** The output surface of the device will have the same dimensions as each of the input surfaces. It shall be capable of resolving an image organized into a matrix of 128 image elements by 128 image elements on .2 mm centers with at most  $\pm .02$  mm center to center error, (i.e.,  $\pm 10\%$  error in alignment). The integrated intensity over each individual element of the output image surface shall be proportional to the arithmetic sum of the intensities at the two corresponding elements of the input image surfaces.

**Efficiency:** The intensity of the output image surface measured at any output element  $C_{ij}$  shall be no less than 30% of the intensity of the arithmetic sum of the intensities of the two corresponding input elements  $A_{ij}$  and  $B_{ij}$ . That is  $C_{ij} = K(A_{ij} + B_{ij})$  where  $K$  will be greater than 0.3. The efficiency of the device will be considered to be the minimum value of  $K$  measured over all elements.

**Uniformity:** The efficiency  $K$ , as defined above, will vary by no more than  $\pm 2.5\%$  over all elements.

Size: The device shall be no larger than 6 cm x 6 cm x 6 cm.

Spectral Response: The device shall meet all specifications  
with inputs from 7000  $\text{\AA}$  to 4000  $^{\circ}$  $\text{\AA}$ .

## DESIGN GOALS FOR IMAGE DUPLICATOR

**Input:** There shall be one input image surface no larger than 26 mm square and capable of being organized into a matrix of 128 image elements by 128 image elements on at most .2 mm centers.

**Output:** There shall be two output image surfaces, identical images shall appear on each of these surfaces. The surfaces shall have the same dimensions as the input surface and be capable of producing two images organized into a matrix of 128 image elements by 128 image elements on .2 mm centers with at most  $\pm .02$  mm center to center error. Each output image shall have the same dimensions as the input image. The intensity of each element of each output image surface will be proportional to the intensity of its corresponding input element.

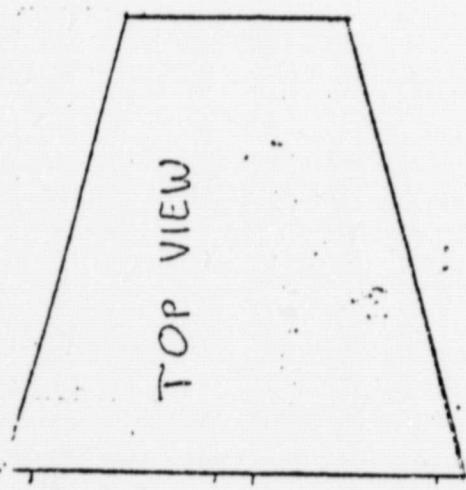
**Efficiency:** The intensity of any element of either output image surface shall be no less than 25% of the intensity at the corresponding input surface element. That is the intensity of output elements  $A_{ij}$  and  $B_{ij}$  will both equal  $K C_{ij}$  where  $K$  is greater than 0.25.

**Uniformity:** The efficiency  $K$ , as defined above, will vary by no more than  $\pm 2.5\%$  over both images.

**Size:** Same as in Combiner.

**Spectral Response:** Same as in Combiner.

PC # 771-34443



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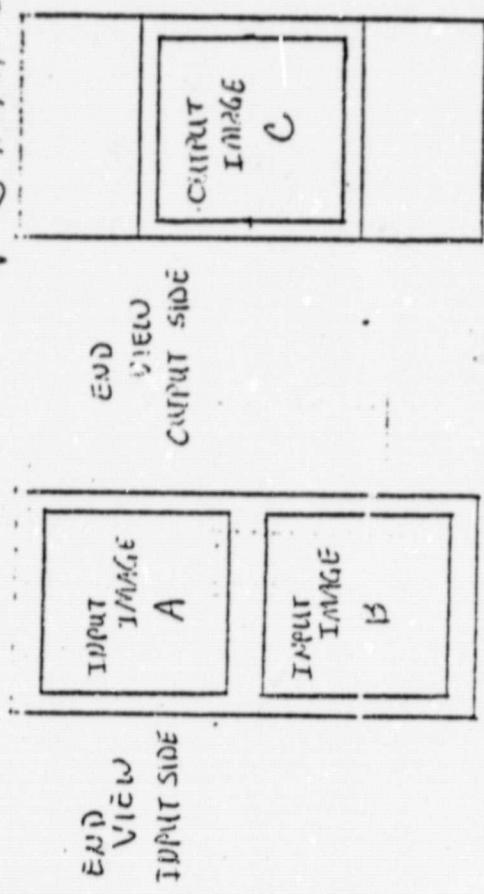


FIG. 4a, CONCEPTUAL DRAWING OF IMAGE COMBINER/Duplicator

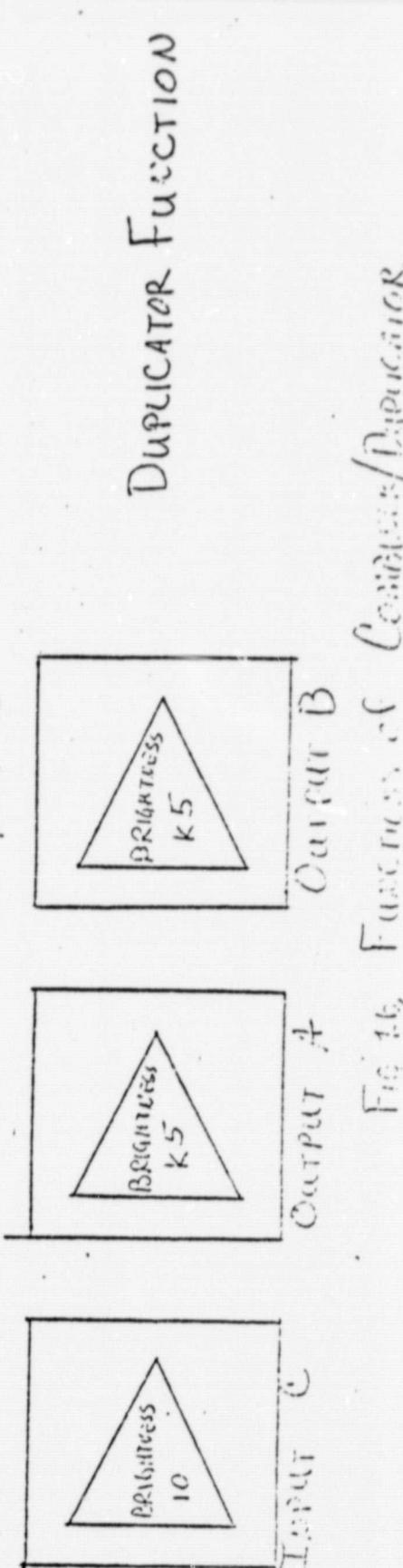
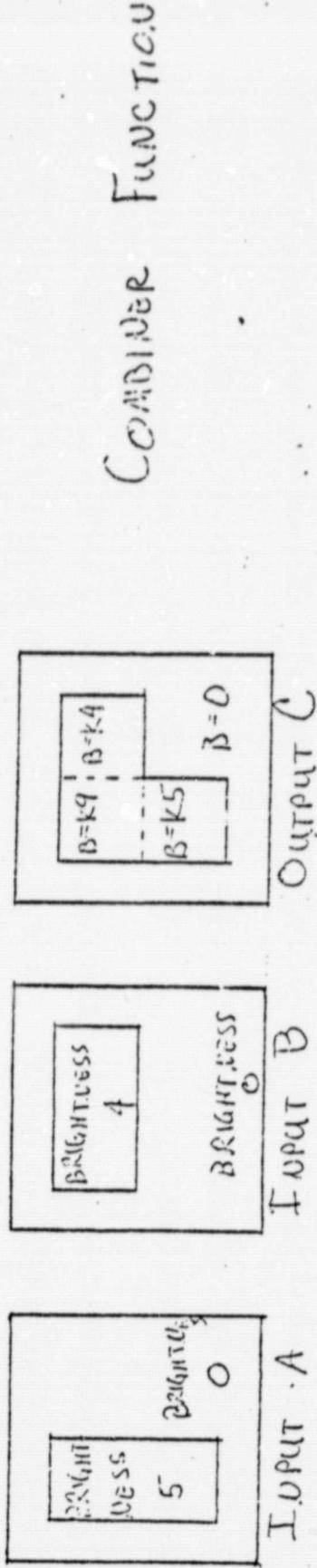
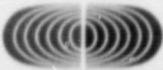


FIG. 4b, FUNCTION OF COMBINER/Duplicator

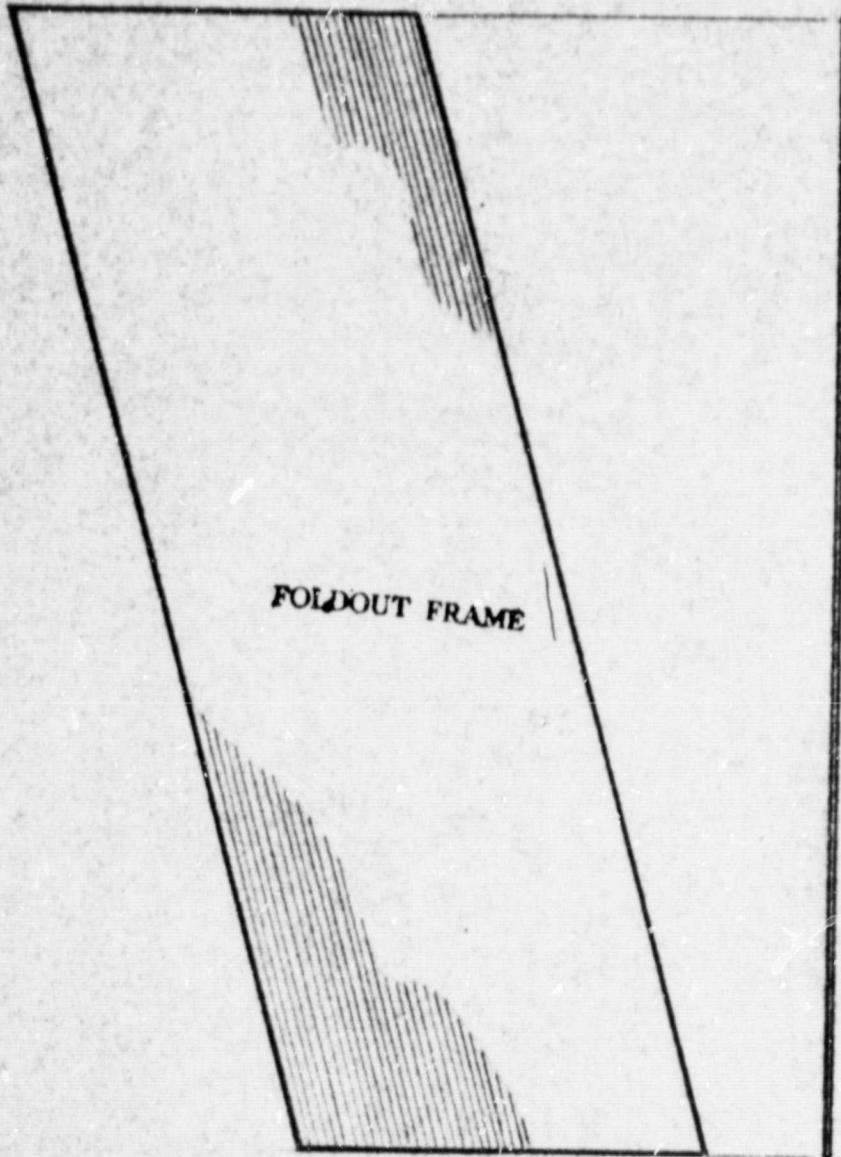


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## APPENDIX B

### Interleaver Assembly Fixture

(GEOC P/N 3557111)



INTERLEAVER  
ASSEMBLY  
Fixture

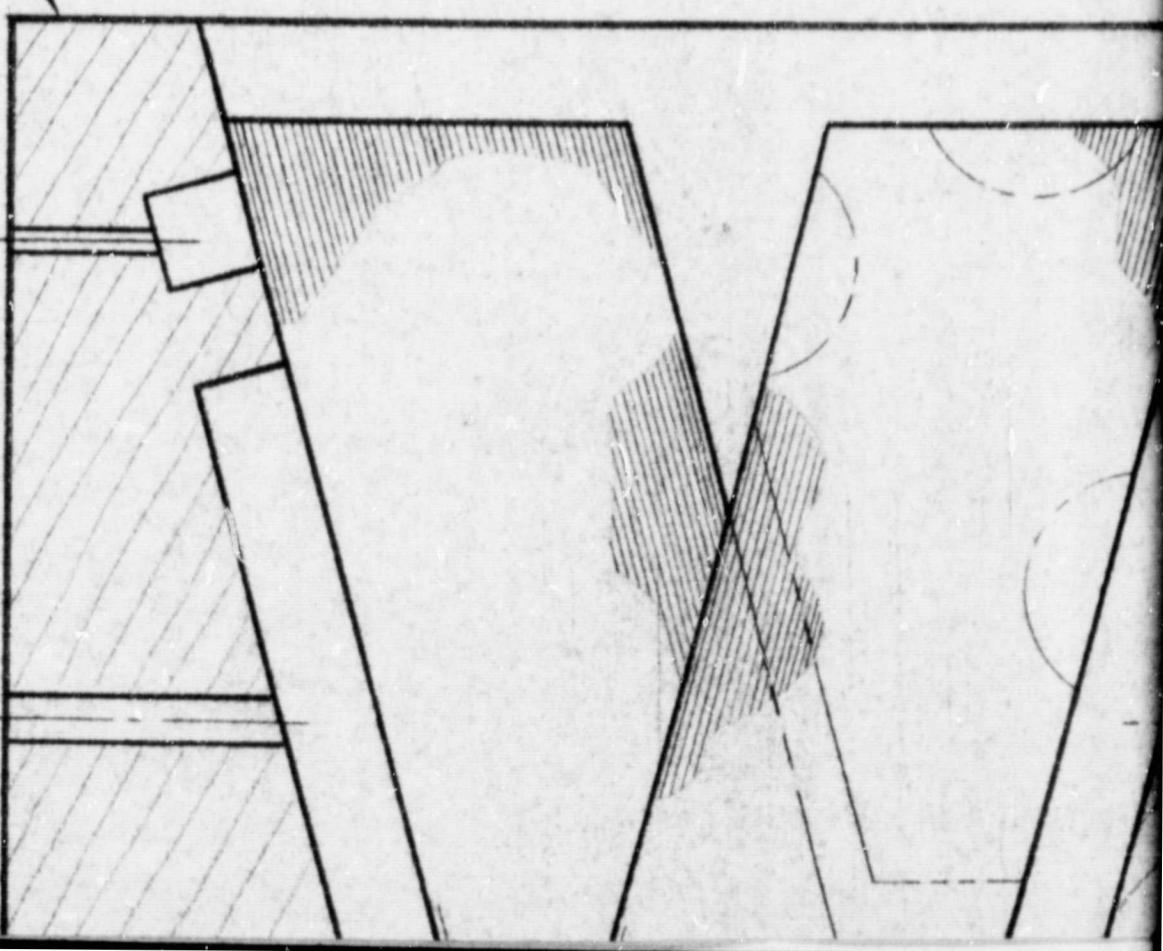
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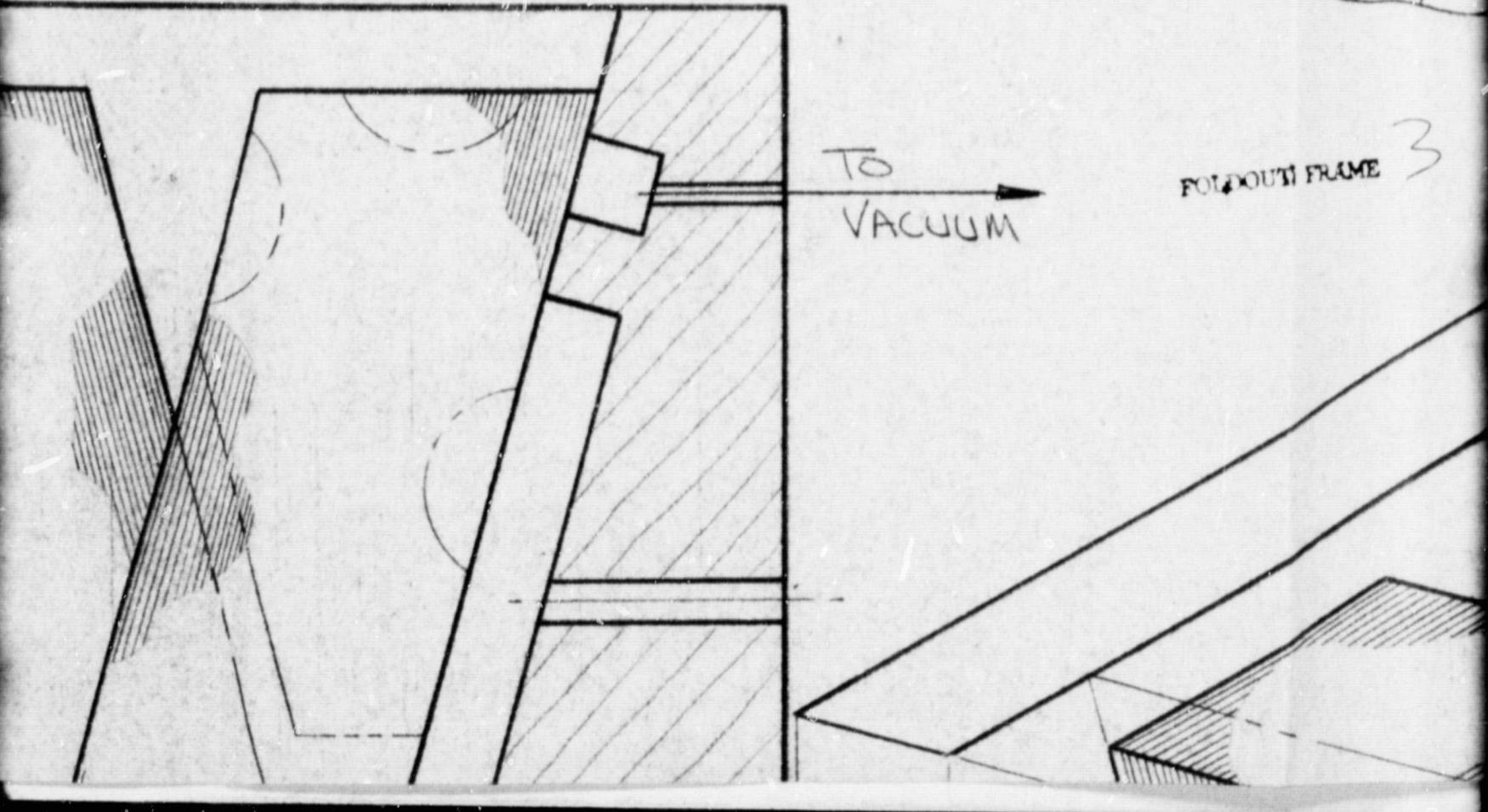
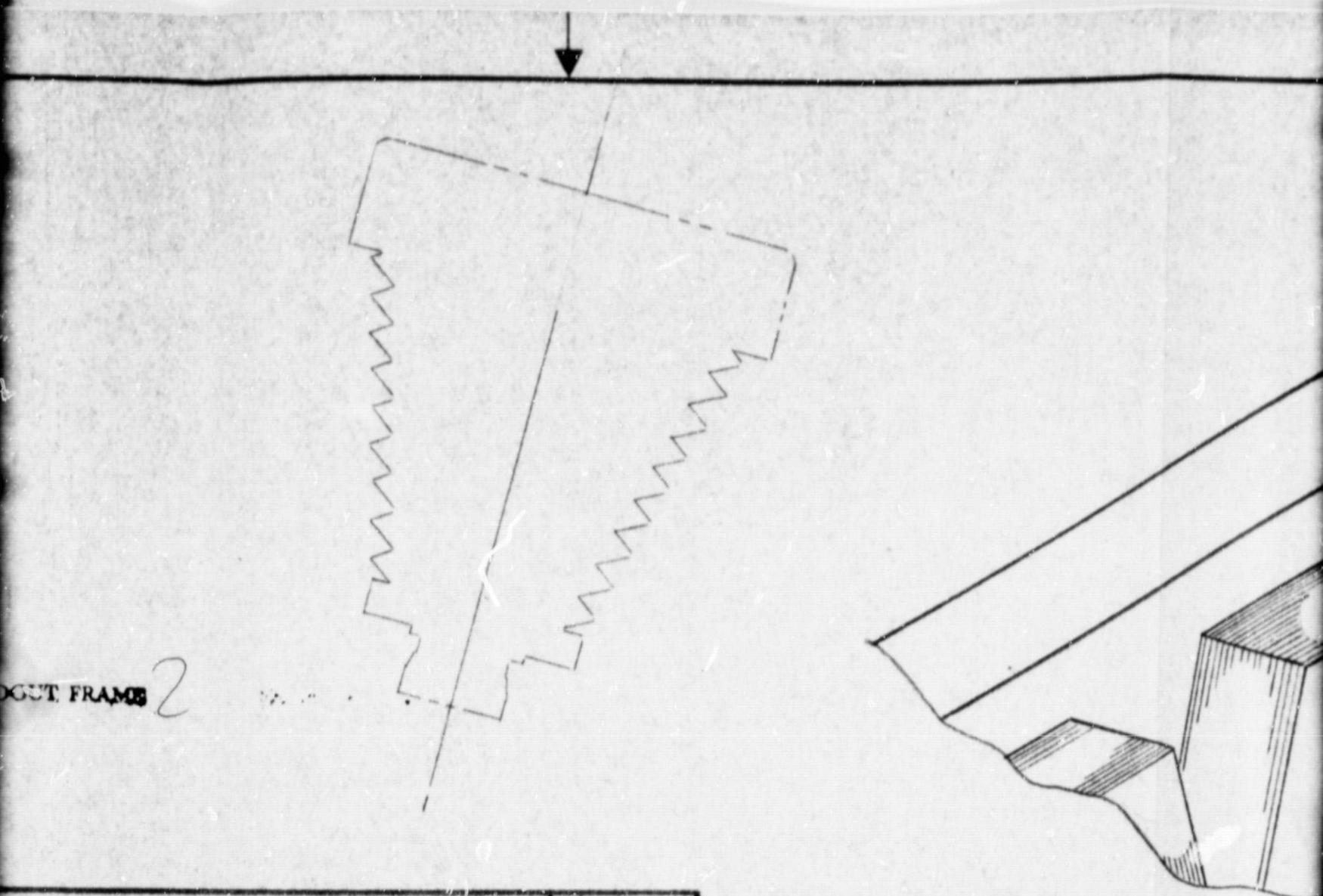
GROUND & POLISHED RIBBONS



FOLDOUT FRAMES 2

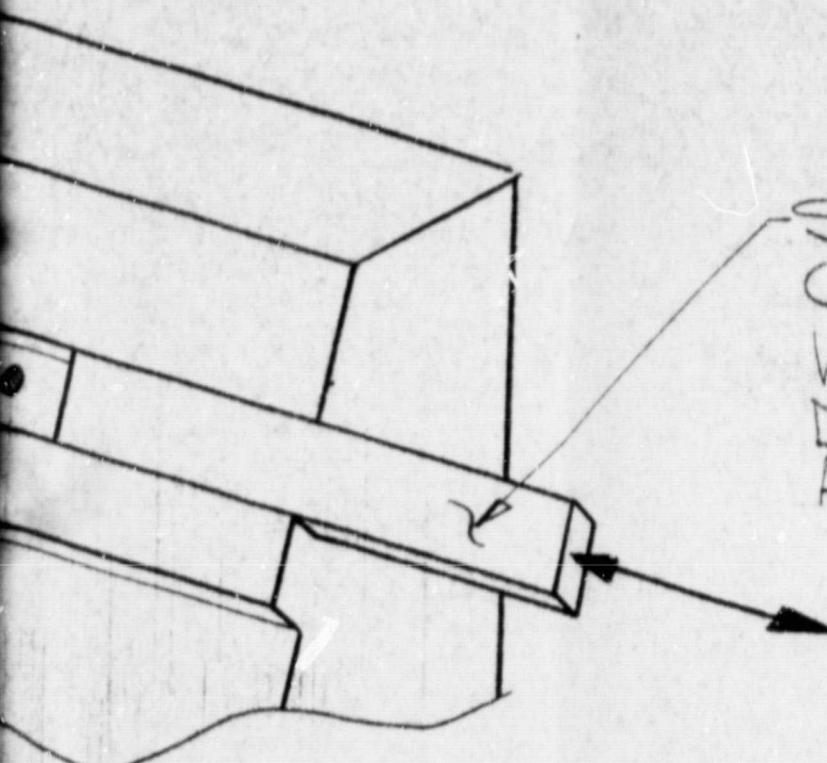
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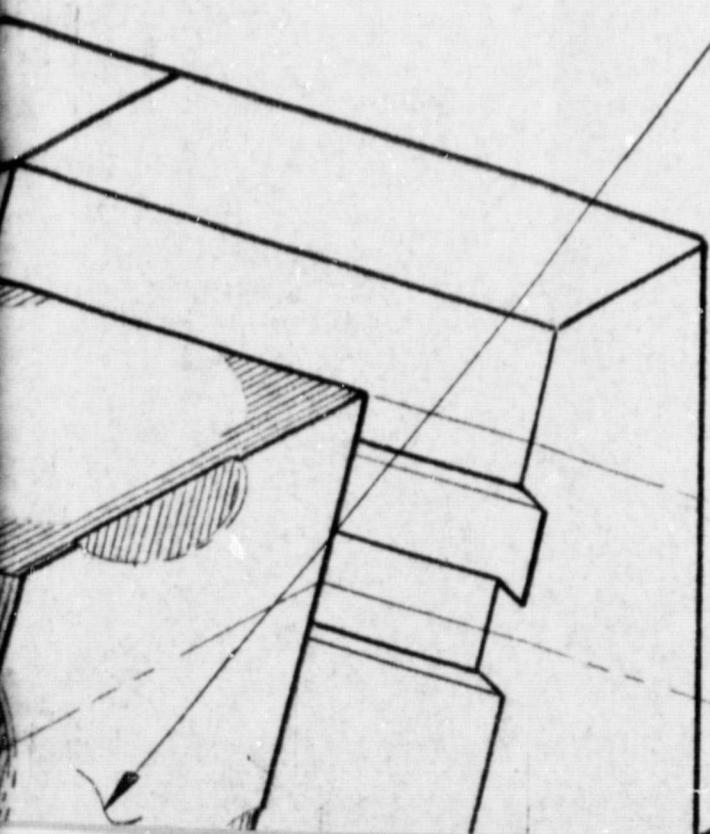


REVISIONS

SYM	DESCRIPTION	CHANGE NO	DATE	APP'D
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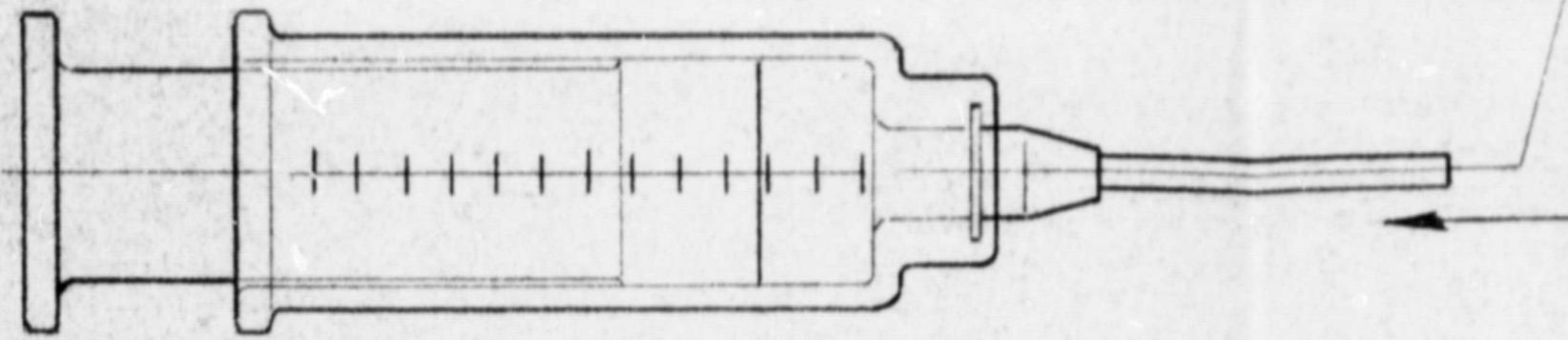
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COVER UNUSED  
VACUUM HOLES/SLOT  
DURING RIBBON  
ASSY.



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BETWEEN ALTERNATE  
LAYERS OF FIBER  
RIBBONS

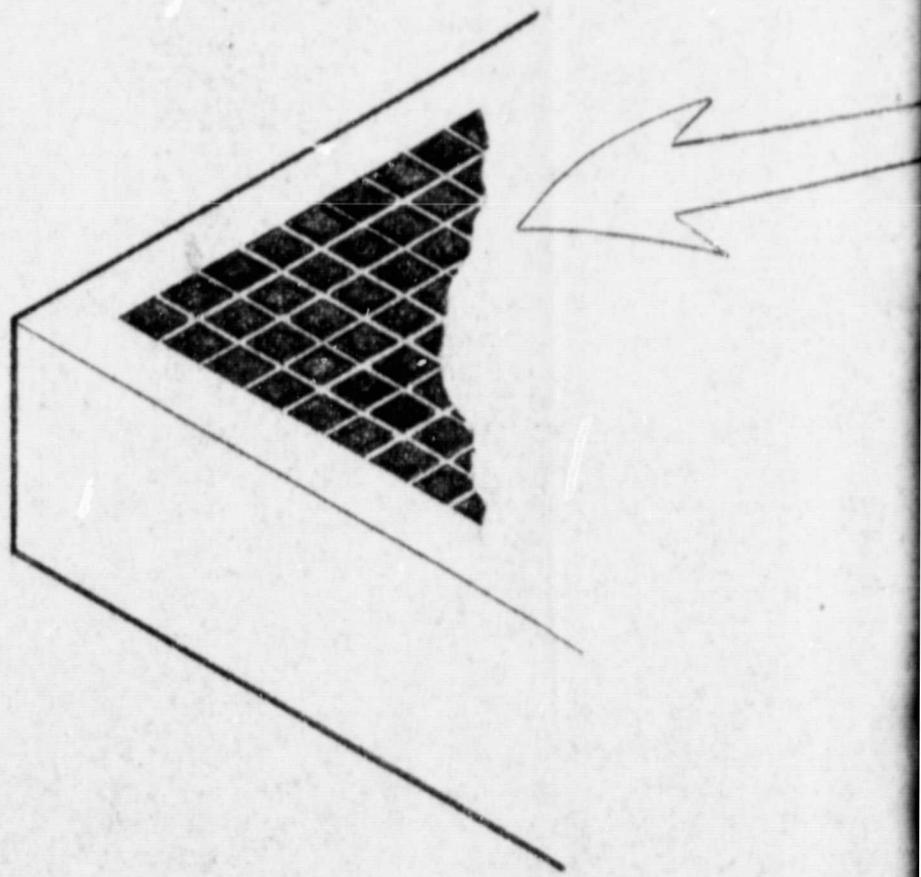
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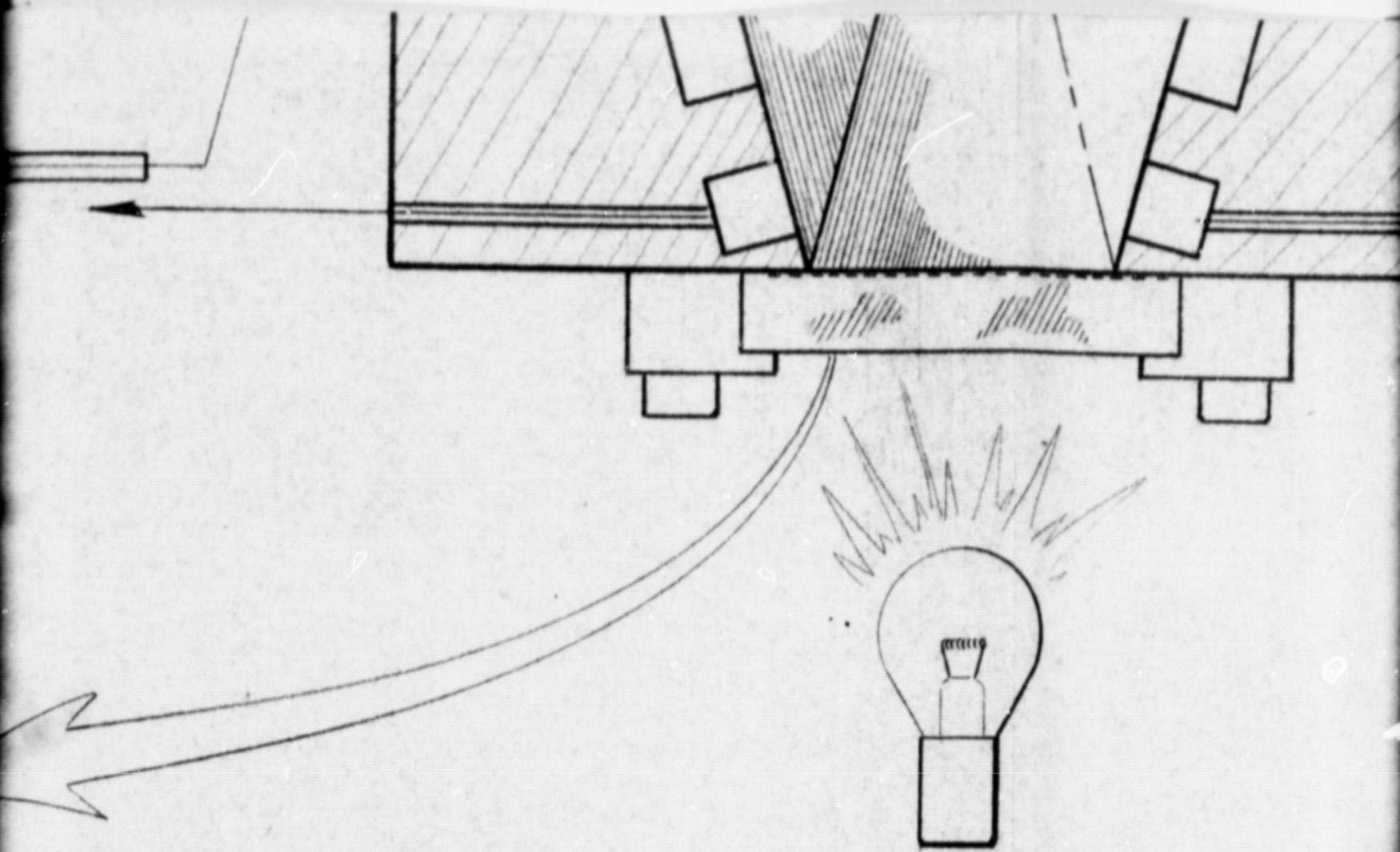


EPOXY SYRINGE

ELLIPSE FRAME



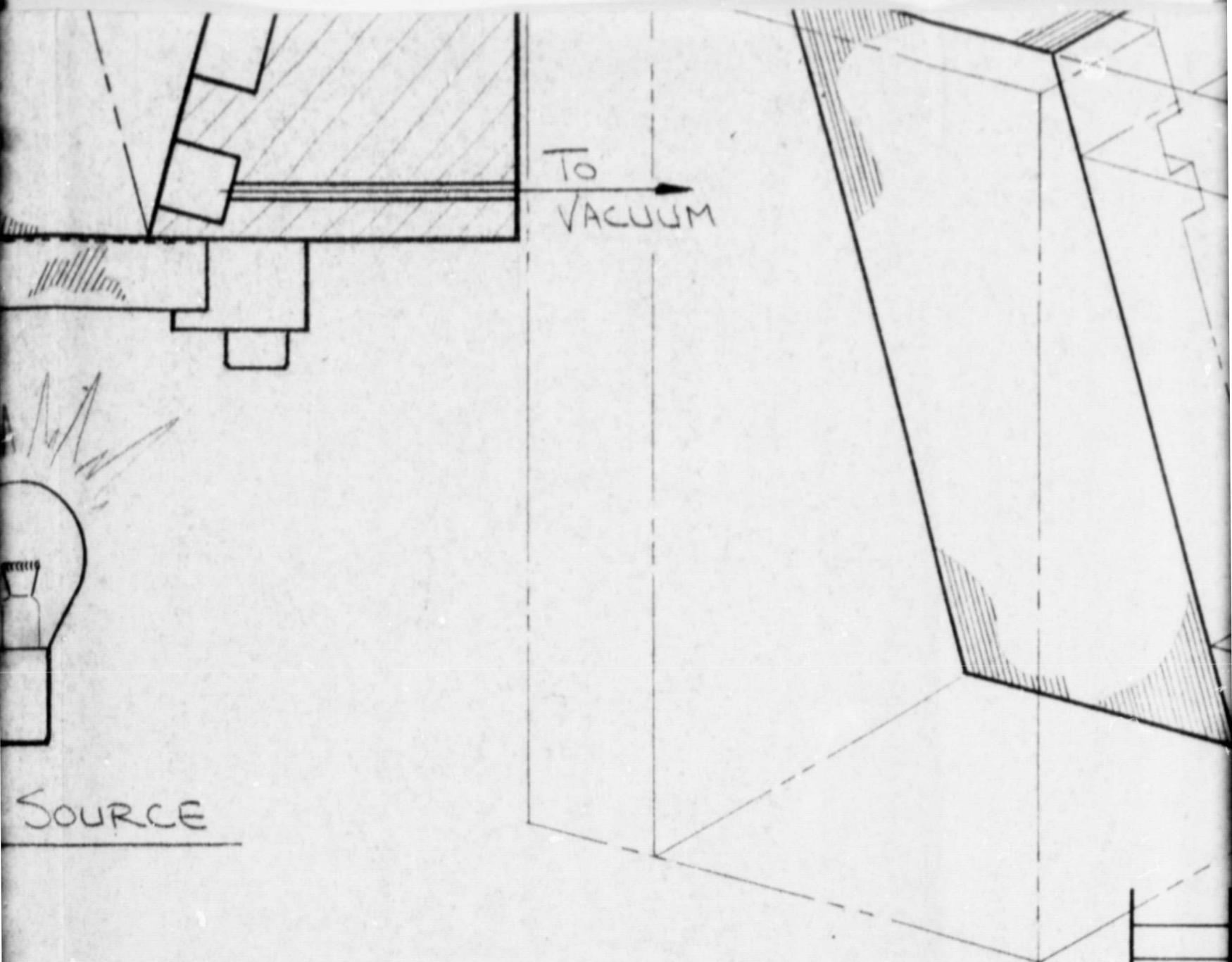
ALIGNMENT TEST MASK (GLAS)



LIGHT SOURCE

PRINTOUT FRAME 6

(GLASS)



EX-100 FRAME 7

ITEM

MATERIAL

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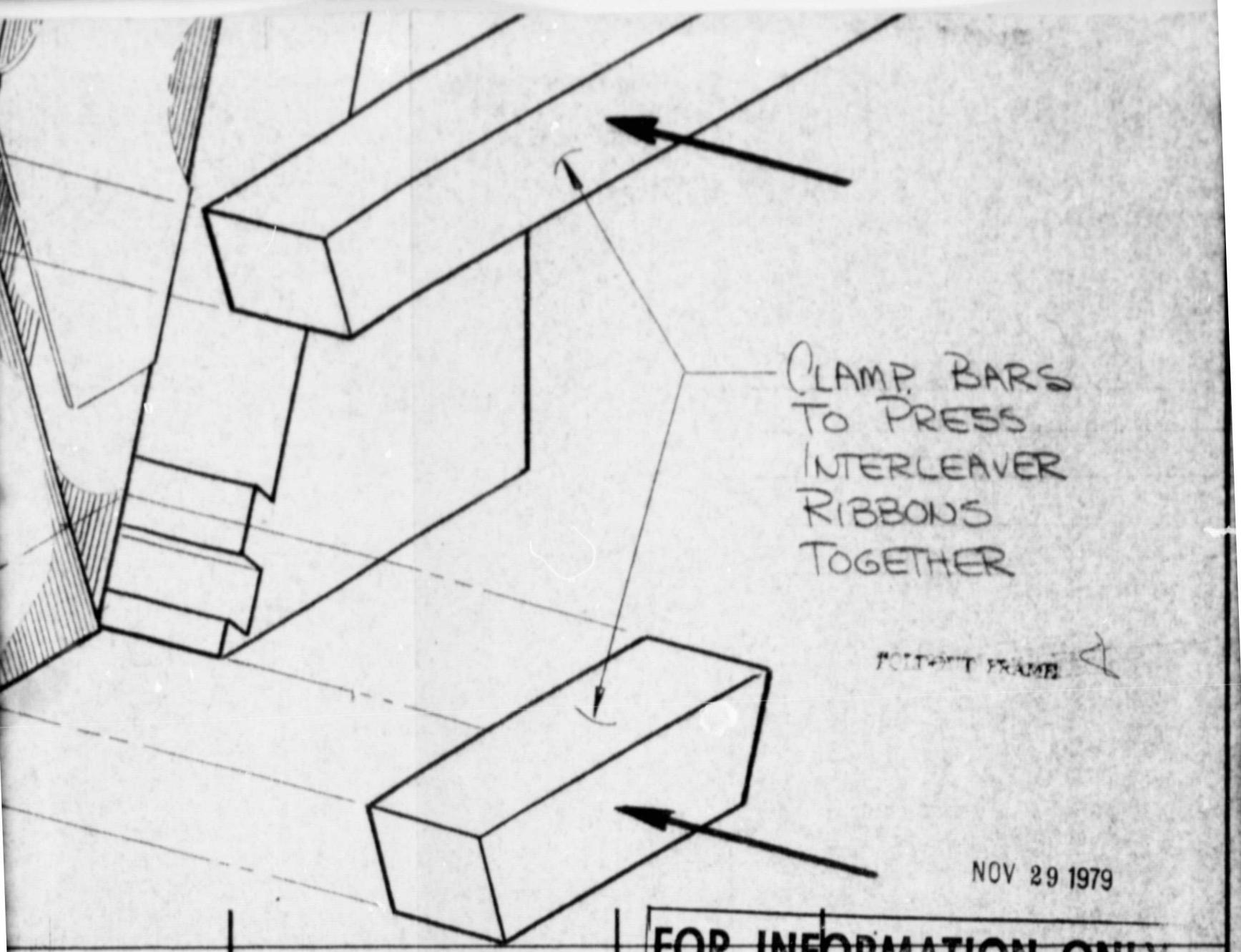
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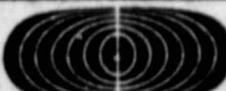
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DESCRIPTION

MATERIAL

SPECIFICATION

NEXT ASSY. NO.

 Galileo Electro-Optics Corp.

STURBRIDGE, MASSACHUSETTS

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TITLE

INTERLEAVER Assy.  
Fixture

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**3557111**

SCALE **1/4**

NOTE

PROJECT **2-7140**

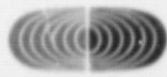
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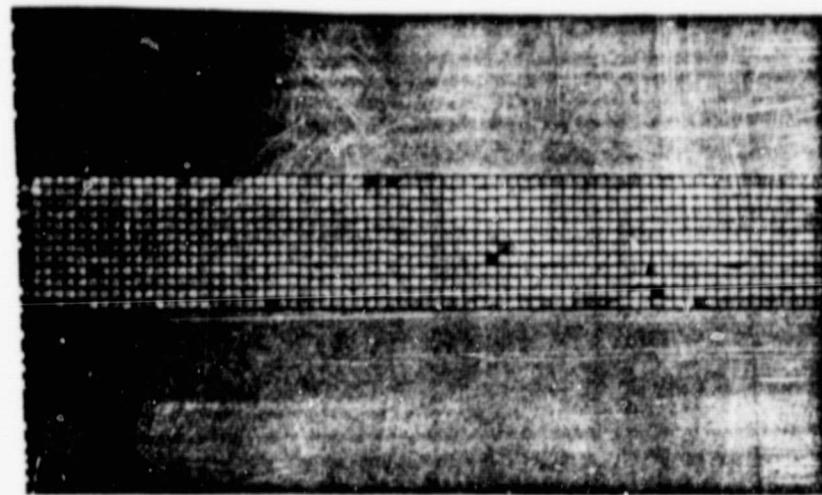
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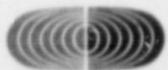


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## APPENDIX C

### XY Configuration Test





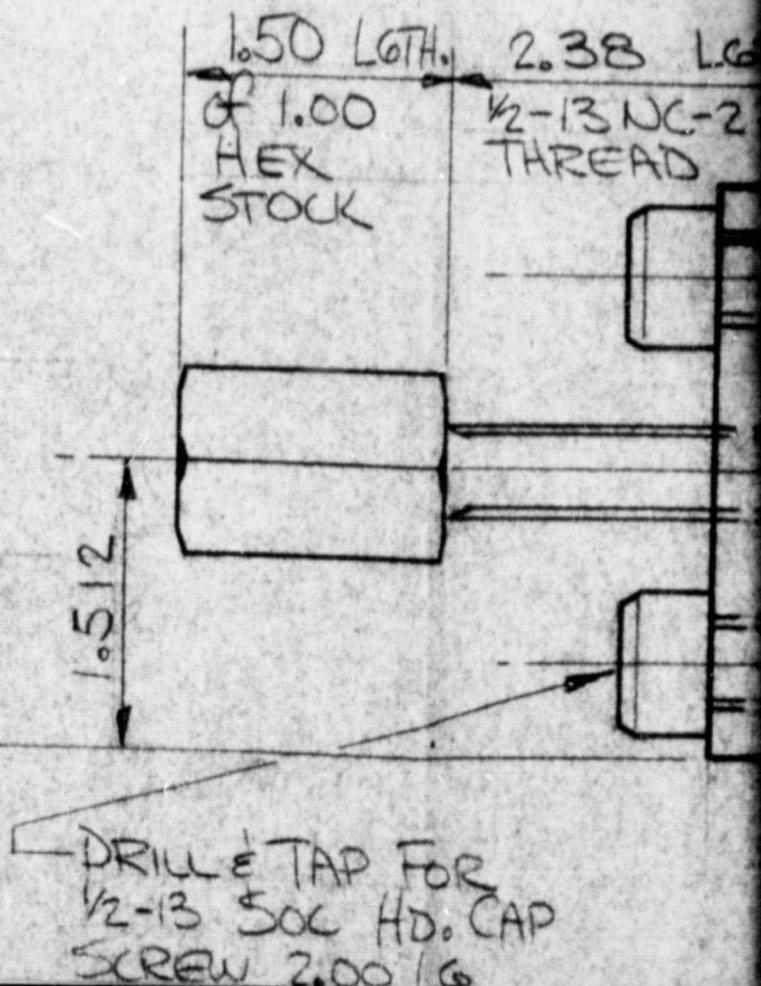
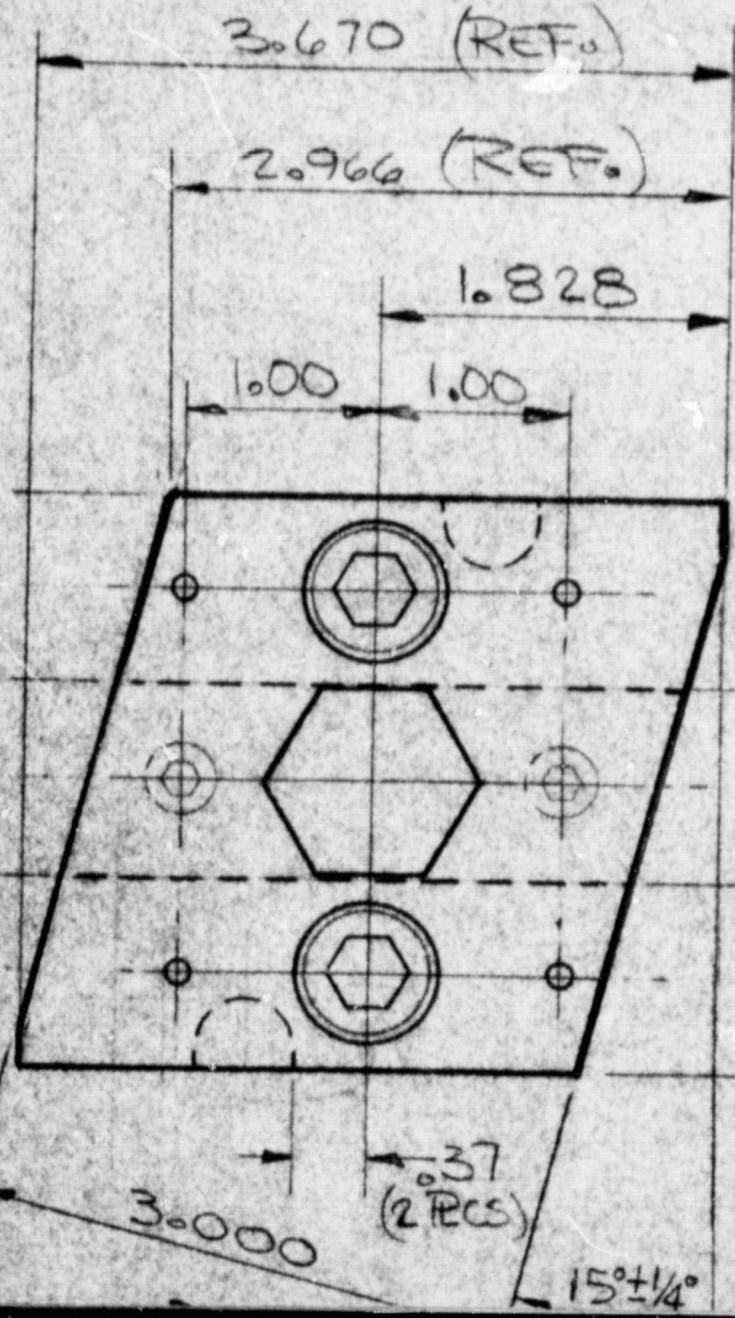
Galileo Electro-Optics Corp.

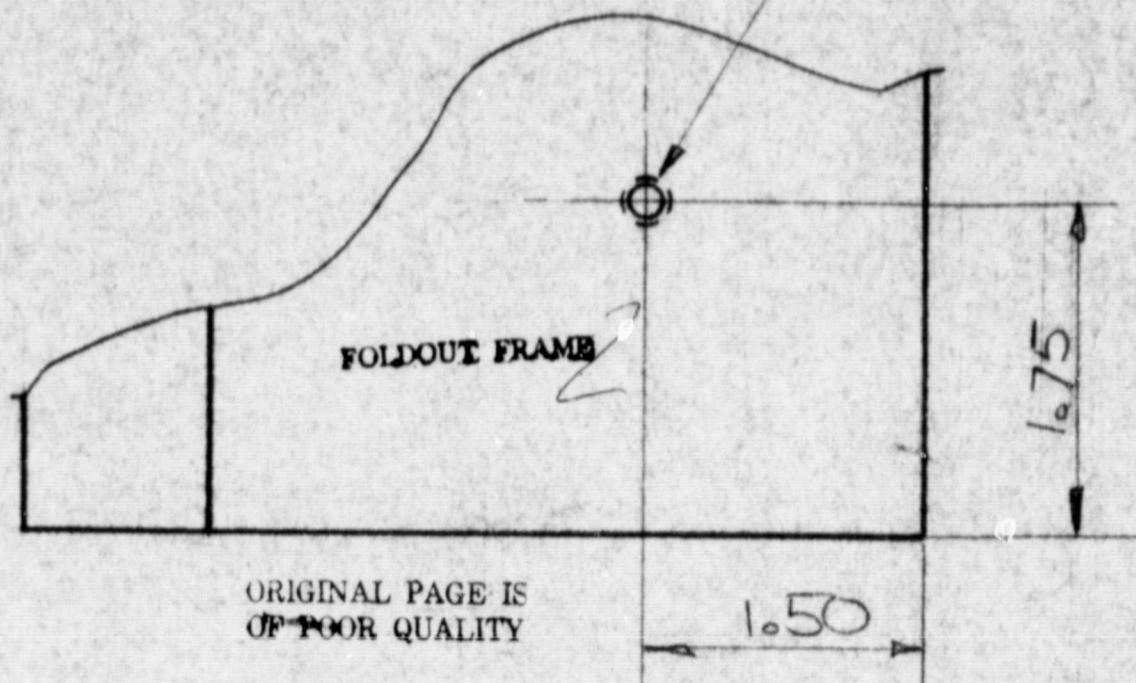
APPENDIX D

Fusing/Polishing Fixture

(GEOC P/N 3557047)

ORIGINAL PAGE IS  
OF POOR QUALITY





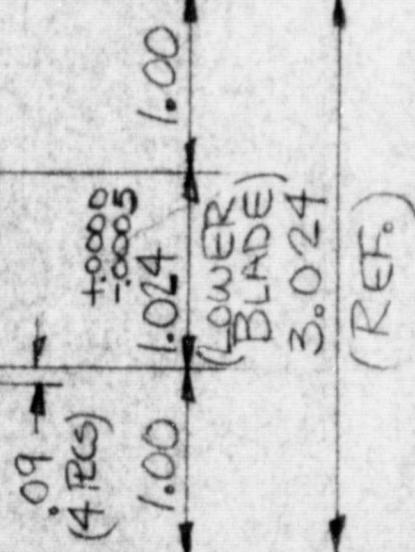
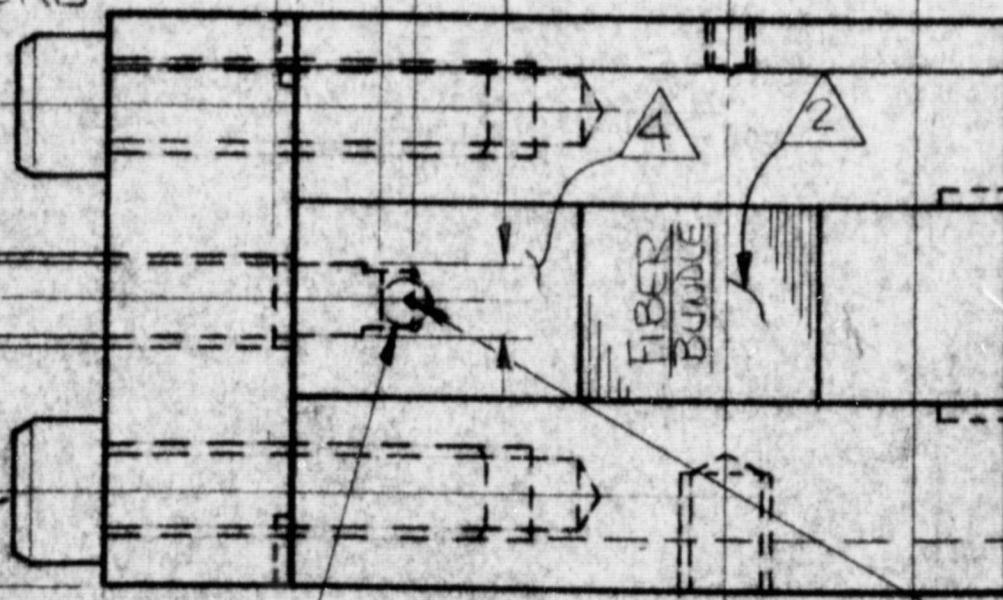
ORIGINAL PAGE IS  
OF POOR QUALITY

.62

2.38 LENGTH of .56  
1/2-13 NC-2A  
THREAD

.375-.008  
.001  
DIA.

1.50



.250 TO  
.375 DIA.  
BALL BEARING

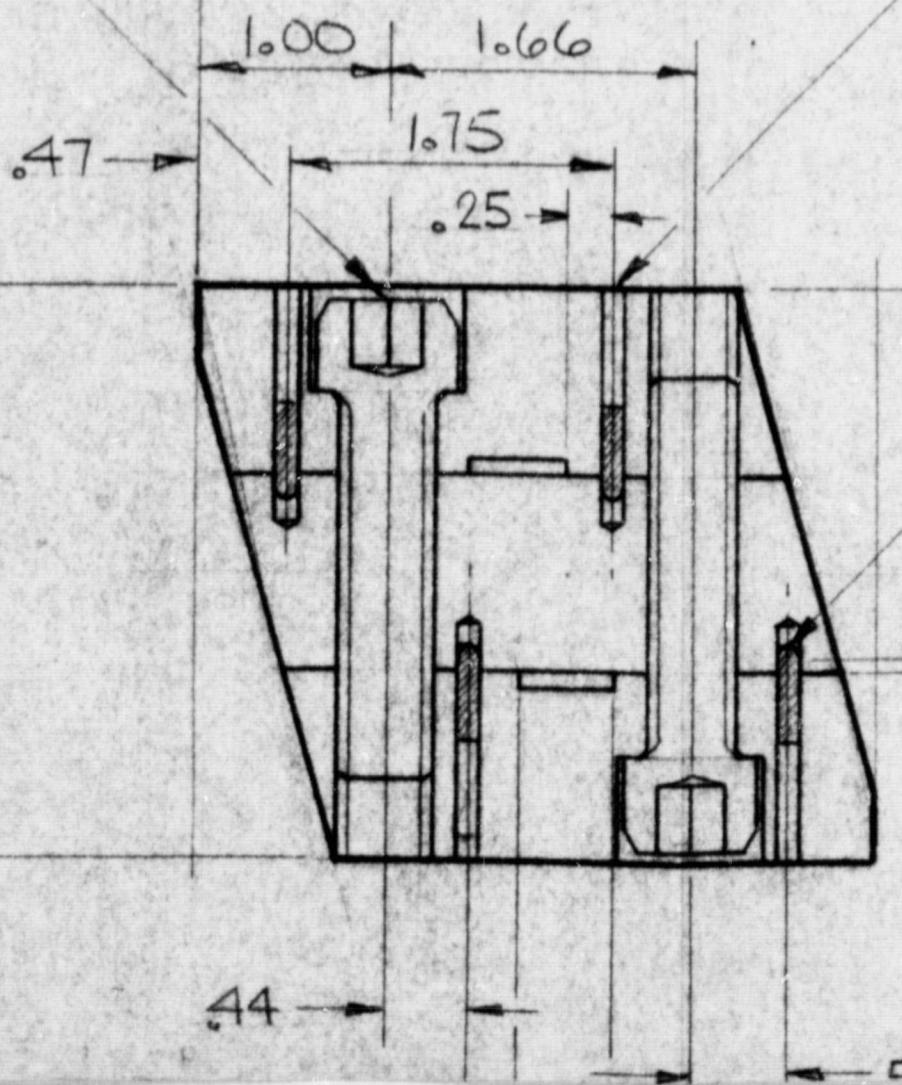
DR  
CAP  
G

TAP  $\frac{1}{4}$ -28 NF-2B

FOLDOOUT FRAME

3

DRILL TAP & C<sup>2</sup> BORE FOR  $\frac{1}{2}$ -13  
Soc. H.S. CAP SCREW 2.00 LG.  
(2 RCS)



NOTES

1. Do Acc BEFOR BUNDU

2

## REVISIONS

SYM	DESCRIPTION	CHANGE NO	DATE	APPROVED
A	RELEASED	7676	SHC	
B	SEE ECN#1594	3/3/76	SHC	

3

ME  
n & PRESS/SLIP  
IA. DOWELS .50  
AS SHN. CRES

FOLDOUT FRAME 4

NOSE

MAX. ENGAGEMENT  
(FIT)

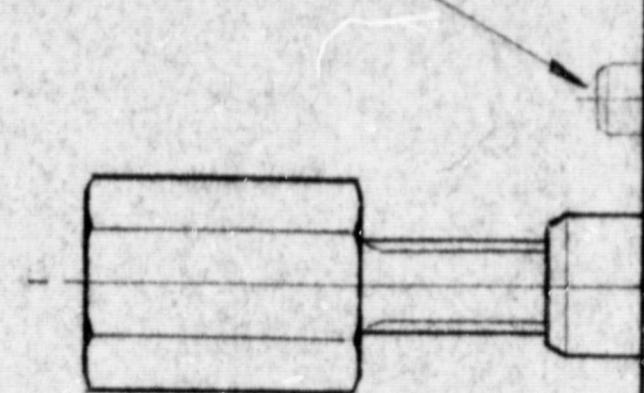
NOTES:

ALL MACHINING, DOWELING, TAPPING, ETC.  
BEFORE MACHINING  $15^\circ \pm 1/4^\circ$  ANGLE (LAST STEP)  
BUNDLE AREA OF FIXTURE TO BE FLAT, SQUARE

-A-  
001  
114-0005

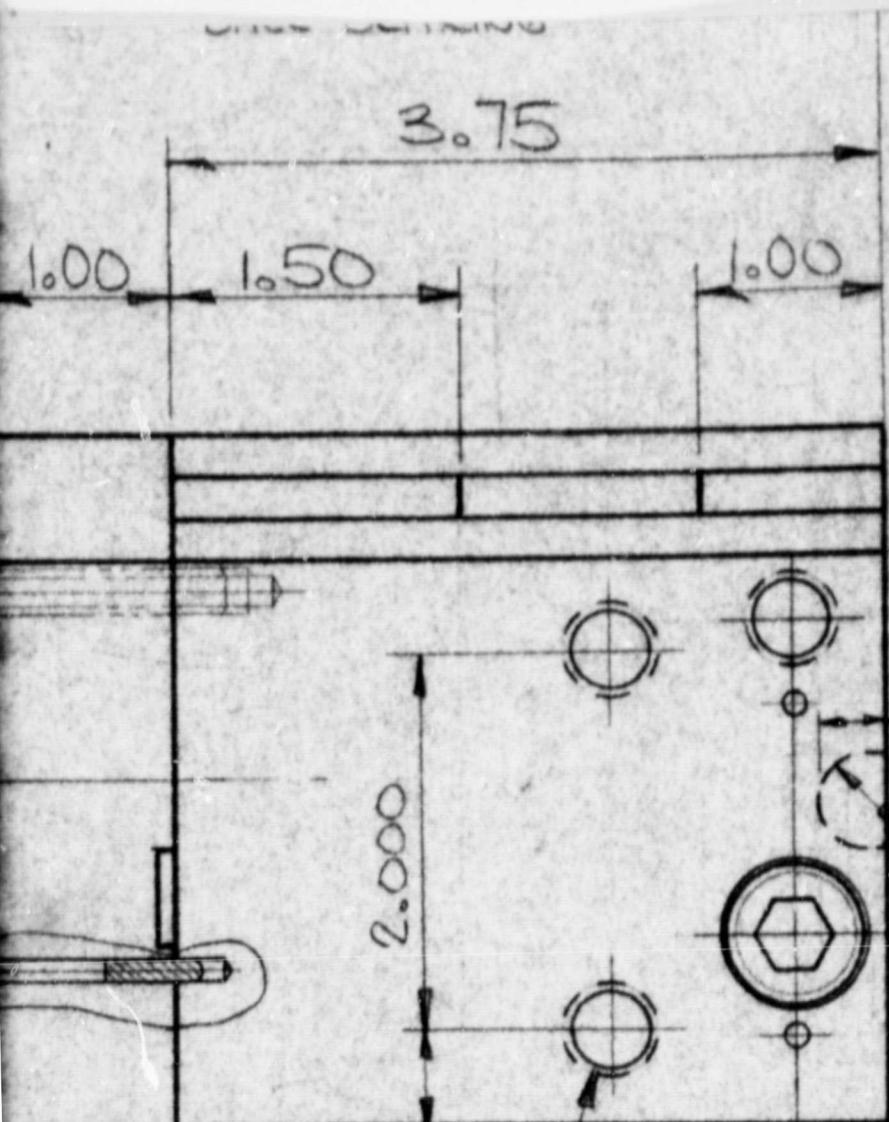
(2 PCS)

1/4-20 Soc. Hd. Cap  
Screws (PERMITTED  
AS SHN.) To Hold  
Upper Blade To  
Top Rate To Machine  
 $15^\circ \pm 1/4^\circ$  Angle



ORIGINAL PAGE IS  
OF POOR QUALITY

~~NO OUT FRAME~~ S



✓  
0.50 DIA  
(END MILL)  
(4 RCS)

DRILL & BOTTOM TAP  
1/2-13 NC-2B .63 DEEP  
(2 RCS)

ROUT OUT FRAME

6

.25

50 WIDE (REF.)  
(PRYING SLOT)  
(4 PCS)



PARALLEL & TO  
SLIP FIT w/.375  
UPPER BLADE  
THAN LOWER B  
WHEN PRESS

5. REMOVE ALL BUT  
EXCEPT IN FIG  
SHARP. SQUARE
6. 125 F.A.O. (MIN.)  
BUNDLE AREA
7. SPOT w/ DRILL  
PER STANDARD

FOLDOUT FRAME 7

ITEM	QTY	DWG. NO.	DATE
MATERIAL:			NEXT ASSY. NO.
CRES 300 Series			
PROCESS:			BY
		DRAWN	J. M. 6
		CHECKED	
		APP'D	A. D. C. 6
UNLESS OTHERWISE SPECIFIED		APP'D	64
DIMENSIONS ARE IN INCHES			
TOLERANCES			
INCHES	MILLIMETERS		
.X $\pm .030$	X $\pm 1$		
.XX $\pm .015$	XX $\pm .5$		
.XXX $\pm .005$	XXX $\pm .10$		
ANGLES $\pm 1^\circ$	ANGLES $\pm 1^\circ$		
		APPROVED	
		APPROVED	
		APPROVED	

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FOR THE PURPOSE OF  
MANUFACTURE OR PROCUREMENT  
OF THE ARTICLE OR PART SHOWN  
HEREON.

PARALLEL & PERPENDICULAR w/in .0005.  
LIP FIT w/.375<sup>.001</sup>-.000 DIA. HOLE.  
UPPER BLADE TO BE .0002 TO .0005 SMALLER  
THAN LOWER BLADE. (TO ALLOW MOVEMENT  
WHEN PRESSING.)

MOVE ALL BURRS & BREAK SHARP EDGES,  
EXCEPT IN FIBER BUNDLE AREA; MUST BE  
SHARP SQUARE EDGES THERE.  
✓ F.A.O. (MIN.) <sup>32</sup> FINISH (MIN.) IN FIBER  
BUNDLE AREA.

POT w/ DRILL POINT IN PRESSING SCREW  
PER STANDARD SHOP PRACTICE

REWORKED

ORIGINAL PAGE IS  
POOR QUALITY

NOV 29 1979

## FOR INFORMATION ON:

DWG. NO.	DESCRIPTION		MATERIAL	SPECIFICATION
Series	NEXT ASSY. NO.		Galileo Electro-Optics Corp. STURBRIDGE, MASSACHUSETTS	
	DRAWN	BY J. M. G.	DATE 3 FEB 76	TITLE FUSING / POLISHING FIXTURE (NASA INTERLEAVER)
SPECIFIED CHES	APP'D	A. DECOW	5 FEB 76	
MMETERS ± 1. ± .5 ± .10 LES ± 1°	APP'D	244	2-6-76	
	APPROVED		SIZE D	CODE IDENT NO. 28719 3557047
	APPROVED		SCALE FULL	PROJECT 2-7140 SHEET 1 OF 1